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Bacteriological quality of drinking water sources based on Settlement types in Njinikom subdivision, Boyo Division North West Region, CAMEROON

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Abstract
The study had as aim to assess the bacteriological quality of drinking water in the study area. Fifty-three water samples from various sources in Njinikom sub division were sampled. The Multiple Tube fermentation Technique (MTFT) was used. Presumptive coliform counts were obtained by the most probable number of coliforms per 100ml of water by making reference to the McCrady's probability table after combination of various positive and negative results. Positive tubes were sub cultured on MacConkey agar and biochemical media for *Escherichia coli* identification. Of the 53 samples tested 13 (24.5%) had *E. coli* in addition to other coliforms which is a probable indication of fecal contamination, 35(66.1%) had only other coliforms without *E. coli* in varying degrees. Only 5 (9.4%) were without coliforms or *E coli*. Gross bacteria pollution was observed for unprotected springs. Mainly alternative water sources such as underground springs, brooks and rivers were largely contaminated indicating closeness to toilets and external contaminants. Measures should be taken to protect drinking water sources, extend municipal water supply coverage and prohibit domestic animals from entering drinking water courses.
Keywords: coliform, drinking water, Njinikom, contaminants.

1.Introduction: The importance of potable water supplies cannot be overemphasized. Water is one of the most important of all natural resources known on earth. It is important to all living organisms, most ecological systems, human health, food production and economic development [1]. The safety of drinking water is an ongoing concern within the global world. Traditionally, the safety of potable water supplies has been controlled by disinfection, usually by chlorination and coliform population estimates. However, it has been reported that coliform-free potable water may not necessarily be free of pathogens[2].With increasing industrialization, water sources available for consumption and recreation have been adulterated with industrial as well as animal and human wastes. As a result, water has become a formidable vector in diseases transmission. Polluted water contains vast amounts of organic matter that serve as excellent nutritional sources for the growth and multiplication of micro organisms. These pathogens are responsible for intestinal infections such as bacillary dysentery, diarrhea, typhoid fever, cholera and paratyphoid fever, amoebiases and helminthiases. If everyone had safe drinking water and adequate sanitation services, there would be 200 million fewer cases of diarrhoea and 2.1 million fewer deaths caused by diarrheal illness each year[3].The aim of bacteriological examination of water is to detect whether contamination with pathogenic bacteria has occurred or not. It is impracticable to directly attempt detection of the presence of the numerous water borne pathogens. Instead, tests for the presence of indicator bacteria which are the common intestinal commensals such as coliforms particularly, *Escherichia coli*, *Streptococcus faecalis*, and *Clostridium perfringens* are done. Their presence indicates the possible presence of other human or animal intestinal pathogens [4] It is not enough to detect the presence of the indicator bacteria, they are also enumerated because the greater their number, the greater

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the danger of infection from the water source. This study utilizes the presumptive coliform count to determine the portability of water sources at the study area as findings can help policy makers to take appropriate actions and provide baseline information for further studies.

2.Material and Methods

2.1.Study area: Njinikom is a Sub division in Boyo division of the North West Region of Cameroon. It is 58km from Bamenda, with a population of about 8,247 inhabitants. Njinikom is hilly, veined with valleys where slopes support quarters and cultivated terraces. It is made up of 21 quarters[5].Njinikom is at 1798m above sea level, It lies between latitudes 06° 23' and 06° 10' N and longitudes 010°30' and 010° 40' E. The area falls under the humid tropical equatorial climate type with 2 distinctive seasons, a long rainy season (mid-March to mid-November) and a short dry season (mid-November to mid-March). Mean annual rainfall and temperature are 1,860 mm and 20.32°C, respectively. Common sources of drinking water here include; protected and unprotected springs, tube wells, brooks, stand pipes in quarters with community water schemes and those with public utility company supply "CAMWATER".

2.2.Sample collection

A total of 53 water sources were sampled in the 21 quarters within Njinikom Sub division. The samples included 18 spring water samples, 27 tap water samples; which were collected in 6 of the quarters with community water and 4 organizational water projects (3 samples each, one from the catchment, and one from the middle of distribution and one at the terminal), 3 samples from the only tube well in the area and 5 samples from CDE.Water samples were collected in bottles sterilized by dry air at 160°C for 1 hour.

Tap water collection; the outside nozzle of the tap was carefully cleaned and the tap turned on fully to run for 2 minutes. The taps were sterilized using an ignited piece of cotton wool soaked in methylated spirit until the whole tap was unbearably hot to touch. And then it was cooled by running the water to waste for 1 minute. The sample bottle was then filled from a gentle flow of water aseptically, labeled and place in an insulated cold box.

Spring water collection; *(protected and unprotected)*; the cap of the sterile sample bottle was aseptically removed and the neck plunged downward to about 30cm below the water surface. The neck was tilted slightly upward to let it fill completely before replacing the cap aseptically. Where there was no current, the bottle was horizontally pushed until it was full. It was then labeled and placed in an insulated cold box.

Collection from the tube well; the hand pump was continuously operated for 5 minutes, and then the nozzle of the pump heat sterilized. Several gallons of water were pumped to waste before aseptically collecting the sample by allowing water from the pump to flow directly into the sterile sample bottle. The cap was carefully replaced; the bottle labeled and placed in a cold box. The samples were transported to the laboratory for bacteriological analysis.

3. BACTERIOLOGY

3.1.Presumptive Coliform Test

The multiple tube fermentation technique [6] was used. In this method, varying amounts of water samples were added to double and single strength MacConkey broth in bottles containing inverted sterile Durham tubes as follows.

1 x 50ml of water to 50ml double strength medium

5 x 10ml of water to 10ml double strength medium

5 x 1ml of water to 5ml single strength medium

The tubes were incubated aerobically at 37°C for 18-24hours after which they were examined for production of acid and gas, changing color to yellow. Sterile distilled water was used as a

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control for each test batch. Presumptive coliform count was obtained by the most probable number (MPN) of coliform per 100ml of water sample by making reference to the McCrady's probability table after combination of various positive and negative results [7].

3.2. IDENTIFICATION OF ISOLATES

Positive tubes of the presumptive test were sub cultured on McConkey agar for the identification of *Escherichia coli*. The inoculated media were incubated aerobically at 37°C for 24 hours, and further characterized by a combination of colonial and morphological characteristics on solid media as well as biochemical tests like; klingler iron agar (KIA)`, Simon citrate, and Motility Indol Urea (MIU) [8]

STATISTICAL ANALYSIS

Microsoft Office Excel 2010 software package was used to sum up data. The mean values of the parameters analyzed were computed for each settlement and types of drinking water sources.

Table1. Contamination according to different types of drinking water sources

TYPES OF SOURCE	TOTAL N° TESTED	N° WITH COLIFORMS AND E. COLI		N° WITH COLIFORMS ONLY		N° WITH NO COLIFORMS OR E. COLI	
		TOTAL	%	TOTAL	%	TOTAL	%
CDE	5	0	0	**2**	40	3	60
TUBE WELL	3	0	0	**1**	33.3	2	66.6
TAPS	27	**3**	11.1	**24**	88.9	0	0
PROTECTED SPRINGS	11	**4**	36.4	**7**	63.6	0	0
UNPROTECTED SPRINGS	7	**6**	85.7	1	14.3	0	0
TOTAL	53	13	24.5	35	66.1	5	9.4

WHO limit for E.coli and Total coliforms = 0CFU/ml

Table 2.Relation between population, location of source and degree of pollution with Community Piped water projects.

COMMUNITY	POPULATION	LOCATION OF SOURCE	POINT OF TEST		MPN	E.COLI
Mbueni	1500	Within settlement	Catchment	1	6	-
			Mid supply	2	10	-
			Terminal	3	18	Present
Bobong	>2500	Within settlement	Catchment	1	5	-
			Mid supply	2	35	-
			Terminal	3	90	present
Muloin	2708	Within settlement	Catchment	1	7	-
			Mid supply	2	18	-
			Terminal	3	40	-
Wombong	>2500	Within settlement	Catchment	1	6	-
			Mid supply	2	13	-
			Terminal	3	30	-
Mughef	>2000	Within settlement	Catchment	1	5	-
			Mid supply	2	40	-
			Terminal	3	180+	Present
Isailah (MFH)	>2500	Within settlement	Catchment	1	1	-
			Mid supply	2	3	-
			Terminal	3	5	-

MPN: Most probable Number

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Table 3.Relationship between populations, location of source and extent of pollution of unprotected springs.

COMMUNITY	POPULATION	LOCATION OF SOURCE	SPRING TYPE	MPN	E.COLI
Mbueni	1500	Farm land	Unprotected	180+	Present
Yang	2930	Within settlement	1) Unprotected 2) Unprotected	180+ 180+	Present Present
Tinifoinbi	3617	Within settlement	Unprotected	180+	present
Balikumato	1801	Within settlement	Unprotected	180+	Present
Bochain	900	Within settlement	Unprotected	35	Present
Atukone	950	Within settlement	Unprotected	90	Present

MPN: Most Probable number

Table 4.Relation between populations, location of source and extent of pollution of protected springs.

COMMUNITY	POPULATION	LOCATION OF SOURCE	SPRING TYPE	MPN	E.COLI
Antenilah	950	Within settlement	1.Protected 2. Protected	10 40	present Present
Atuilah	>1500	Within settlement	1. Protected 2. Protected	10 40	present Present
Mungongo	>1000	Within settlement	Protected	180+	present
Kikfuni	>3000	Within settlement	1.Protected 2.Protected	30 180+	present present
kindo		Within settlement	Protected	40	present
Baichi	1182	Within settlement	Protected	35	Present
Asuchu	>2500	Within settlement	Protected	180+	present
Atukone	950	Within settlement	Protected	30	present

MPN: Most Probable number

4.RESULTS

Findings of the study show that 5 CDE samples were tested and none had *E. coli* while 2(40%) had other coliforms. Of the 3 samples tested for tube wells, none had *E. coli* but 1(33.3%) had other coliforms. Of the 27 taps tested, 3(11.1%) had *E. coli* and 24(88.9%) had other coliforms. For protected springs, of the 11 tested, 4(44.4%) had *E.coli* and 7(63.3%) had other coliforms only. Out of 7 unprotected springs samples, 6(85.7%) had *E. coli* while only 1(14.3%) had other coliforms. Thus, of the 53 samples tested, 13(25%) had *E. coli*,35(66.1%) had other coliforms only 5(9.4%) had neither *E.coli* nor other coliforms as seen on table 1 below

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Bacterial contamination increased with increase distribution as shown by the most probable number of coliforms (MPN). Only 3 of the sources had *E.coli*. Population ranged from 2000 to >2708.Accordingly, coliforms were present in three of community settlements, particularly at the terminus of the point of use, as seen on table 2.

Meanwhile, out of the 7 unprotected springs analyzed; 6 were within settlement and only one out of settlement, but in farming land. Only one had no *E.coli,* with all grossly polluted with reference to the most probable number (MPN) of coliforms, ranging from 35 to 180+. Population ranged from 900 to 3617(table 3).

For the 11protected springs analyzed; all were within settlement; 4 had *E.coli* with all showing most probable number (MPN) of coliforms ranging from 10 to 180+. Population ranged from 950 to 3000 as seen on table 4.

5. Discussion

In this study, of the 53 sources sampled, 13 sources had *E.coli* which is an invariable indicator of fecal pollution (Table 1). Gross pollution was seen with unprotected springs which could probably be because of their location within settlement (Table 4), and their open or insecure nature exposing them to contamination from varied sources like; surface runoffs from land and to attracting animals and water fowls as fecal contamination sources. This is similar to the findings of [9], which incriminated animal rearing around water sources, to be potential sources of faecal coliforms in wells, due to dung they deposit as they feed around. Protected springs are defined as those which are properly covered by a stone masonry with one or two boxes, and a distribution site, also showed the presence of *E. coli* in some cases (Table 4). This may probably mean that the protection was poorly built or there is damage to the lining allowing ingress of contaminants or inappropriate cleaning or insufficient treatment processes, including disinfection of the source by the concerned bodies. However, the location within settlement with pit latrines above and around the springs might probably be the source of contamination. This is in conformity with a related study carried out in Nigeria by [10] that revealed open springs are liable to various sources of contaminants. Community piped water as well as organizational piped (Table 2 and 3) which according to [11] is easily treated and is considered safe, showed some coliform contamination mostly at the terminus of distribution. This probably indicates that contamination occurred along distribution and not in the catchment in conformity with the study of [12] and [13] who reported that waterborne diseases in USA involved contamination at or in the source, treatment facilities or in distribution systems. This suggests a possible leakage along distribution giving room for the seepage of contaminants into the distribution pipes. Also, the location of the catchment within settlement shows that pipelines will probably pass near sewers and domestic animal fences whose feces could have entered the system because of low internal pressure, pipe burst or when new water mains are installed potentially leading to the introduction of contaminated soil or debris into the distribution system [7]. This may account for the presence of *E. coli* in some of the tap water sources. This findings therefore confirm the hypotheses that the larger the population served, the longer the distribution system and the greater the risk of contamination [14] and differ only in relation to population in this study, suggesting that hygiene and sanitation and not only population density relates to contamination.Finally,this study revealed that groundwater that is covered, though considered safe, needs to be treated prior to human consumption. Likewise, the mean microbial counts(cfu/ml) of the samples both within and without settlement proved to be for most beyond the WHO

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recommendations[15,16],unacceptable for human consumption, and so calls for proper disinfection and monitoring, besides awareness creation to local indigenes.

6.Conclusion

On the basis of criteria set by WHO, the water sources used for drinking and other domestic chores in Njinikom subdivision were not found to be potable in terms of bacteriological safety. The identification of potentially pathogenic bacteria such as *E. coli* was a good indicator of safety problems. The protection of water sources and distribution systems is essential for providing safe drinking water and prevents water borne dissemination of diseases. Because of the nature of the distribution system, which may include many kilometres of pipelines, location of sources and storage tanks, type of source, interconnections, coupled with hygiene and sanitation of population, opportunities for microbial and chemical contamination exist. This contamination can occur at source, treatment units, within the distribution system, or at the point – of – use. The contributing factors include location, type of water source as well as hygiene and sanitation of the population revealed in this study. However, the enumeration and serotyping of *E.coli,* complete physic-chemical analysis, isolation and differentiation of other pathogens and their health impacts are probable areas for further investigation which will help policy makers to put in place adequate water, sanitation and health management programs.

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8.Conflict of interest. The author declares there is no conflict of interest.

9.Cover statement

This is to indicate that this article is fruit of our original research and that this article has not been submitted elsewhere for publication. Wherever information is adapted, the author has provided adequate citation.

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